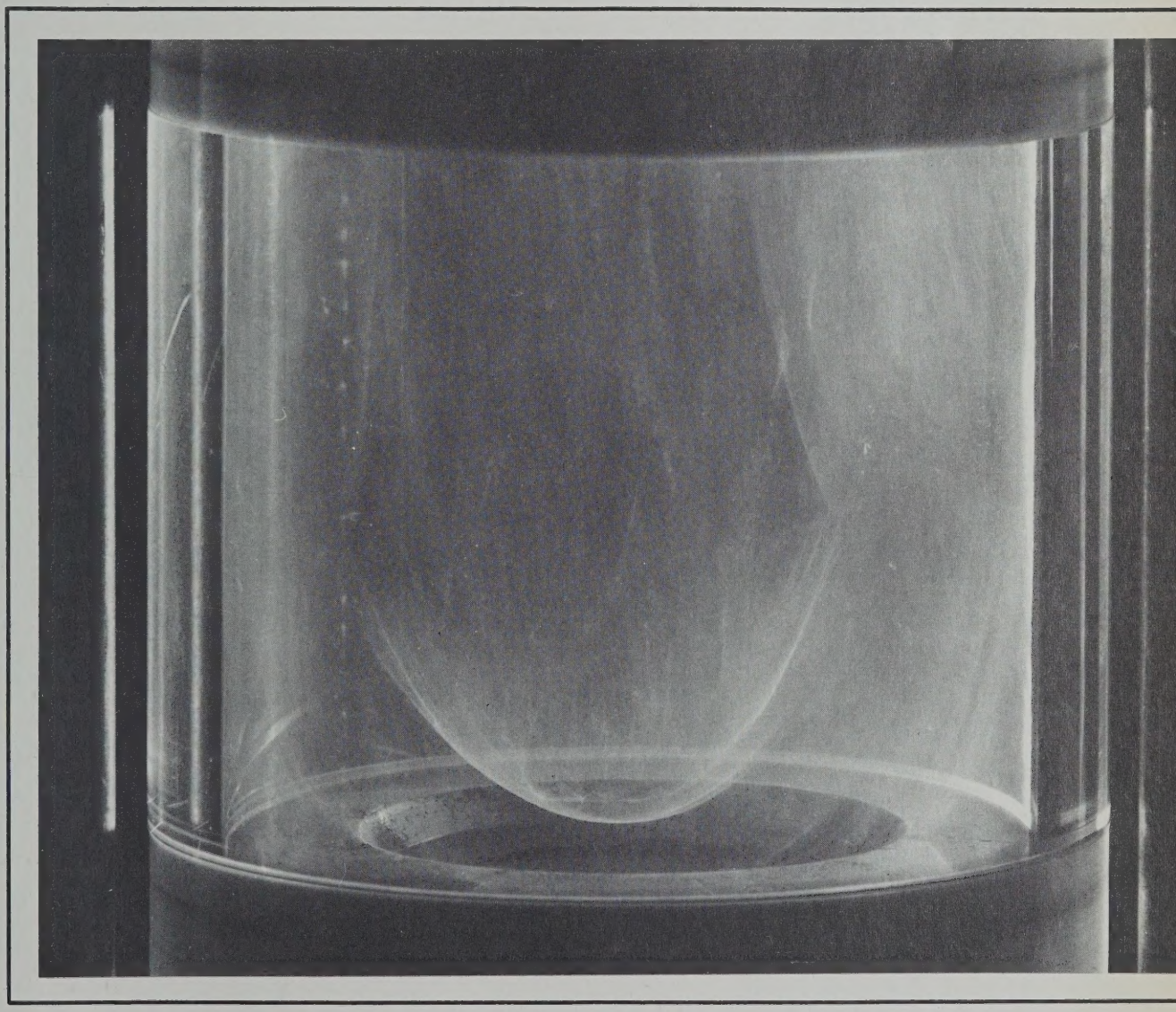
NATIONAL BUREAU OF STANDARDS December 1966

Technical News Bulletin



U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

DECEMBER 1966/VOL. 50, NO. 12/ISSUED MONTHLY

U.S. DEPARTMENT OF COMMERCE
John T. Connor, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

CONTENTS

233 Defects described in quenched alloys

235 Standards and calibration
- Summary of 1965–66 NBS precision measurement seminars
- Calibration service for microwave power in WR 187 waveguide (3.95 to 5.85 GHz)
- Calibration services for waveguide reflectors in WR 112 and WR 187 waveguides
- Standard frequency and time broadcasts

237 Standard reference materials
- Tearing strength standard for paper renewed

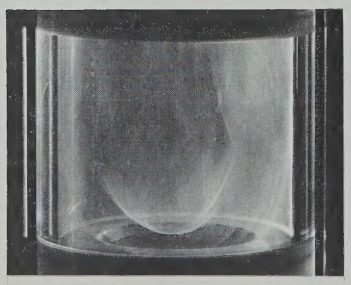
238 NBS studies light from exploding wires

240 NSRDS news

243 Publications of the National Bureau of Standards

244 Index to the Technical News Bulletin

Insert—Precision measurement seminars



A view of the explosion chamber used in exploding wire experiments. The residue from a wire explosion has formed a paraboloidal pattern approximately one hour after an explosion. *(Story on page 238)*

Prepared by the NBS Office of Technical Information and Publications
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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized into three institutes—
- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of all three institutes.

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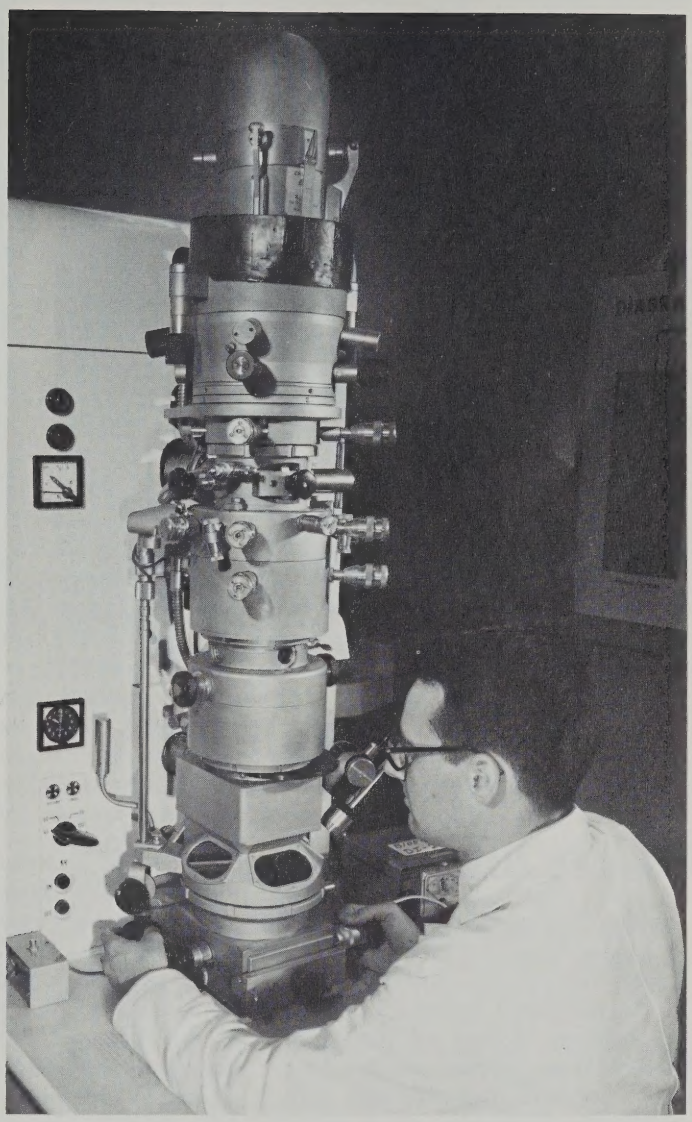
NBS scientist L. K. Ives adjust the position of the silver-tin specimen within the electron beam of the transmission electron microscope. This instrument allows direct observation of the alloy defect structure in depths up to 2500 Å and in areas over the range of several square millimeters.



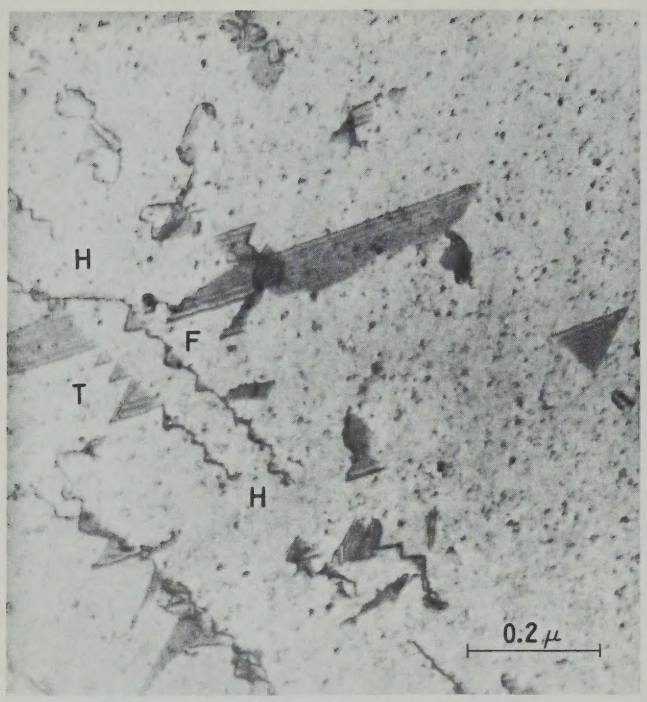
Defects Described in Quenched Alloys

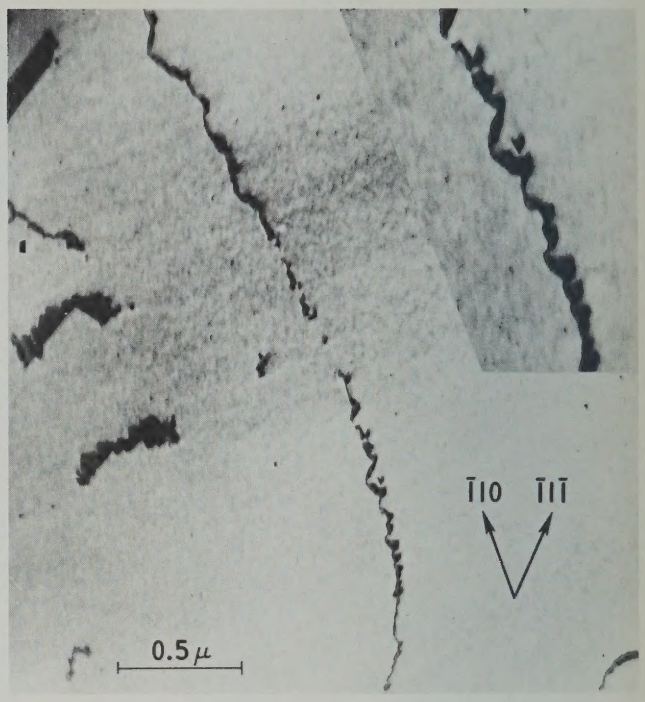
Important properties such as strength and hardness in metals and alloys depend directly on the number and type of defects in the material. In a recent study at the NBS Institute for Materials Research, A. W. Ruff, Jr., and L. K. Ives have investigated the defect structure in alloys with low-stacking fault energies and have explained theoretically the formation of particular imperfections in these alloys.[1] Their results provide materials scientists with information that is useful in understanding the strength, elasticity, and fabrication of particular binary solid-solution alloys.

A typical imperfection in certain classes of solids is the stacking fault defect, which is a misalinement of layers of atoms in a crystal structure. Materials that contain many defects are highly strained, and to relieve these internal stresses new imperfections may form in the solid causing the strain energy to be lowered. The type of defect that forms depends on the strain energy available and on the stacking fault energy.

As part of a fabrication treatment, many metals and metallic alloys are heated to very high temperatures, and then quenched. Such heating causes lattice vacancy defects to form in the material at the high temperatures, and when the material is quenched, the imperfections are trapped in the structure. Previous studies on materials [2] have shown that these quenched imperfections cluster about existing screw-type dislocations (a spiral array of atoms within a regular three dimensional lattice of atoms). These

continued





Left: this photomicrograph of a silver-tin alloy shows stacking fault defects (at F) in the turns of the helices (at H). Additional stacking fault tetrahedra (at T), which are inclined to the surface as indicated by the fringes, are shown in rows extending from a helix.
Right: photomicrograph of the silver-tin alloy used in the NBS study shows clustering of defects at an existing dislocation with the helical shape of the cluster visible in the insert (×4). Small stacking fault segments can be seen forming in the turns of the helix, which revolves around the (110) crystallographic direction.

QUENCHED ALLOY *continued*

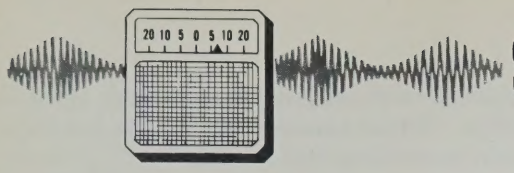
clustered imperfections are observed as helices some of which then break up into dislocation loops (single turns of the individual helices) to relieve the internal stresses of the metal. Most of these previous studies, however, have been of metals with high-stacking fault energies, which do not easily form stacking fault defects.

In the present study, silver-tin, a metallic alloy with a very low-stacking fault energy was investigated to determine the defect structure present in this type of alloy. Thin sheets of the alloy were heated to 600–750 °C and then quenched. The sheets were next electropolished to produce samples for study. Photomicrographs of the imperfections in the alloy, after quenching, were made with a transmission electron microscope.

Examination of the photographs showed that the latice vacancy defects that formed also clustered about screw dislocations. In was found, however, that the helices (formed by the clustered defects) produced stacking fault tetrahedra instead of dislocation loops. These tetrahedra are three dimensional figures within the solid lattice. It was theorized from these results that the stacking fault tetrahedra were created by unfolding the helices. Because the helices lie along certain crystallographic directions, the hypothesis was strengthened by the observed result that the stacking fault tetrahedra were also alined in rows along known crystallographic directions.

[1] For further technical details, see **Quench defects formed in a low stacking fault energy silver-tin alloy**, by A. W. Ruff, Jr., and L. K. Ives, J. Appl. Phys. **37**, 3073–3079 (1966).

[2] The proceedings of a recent conference on quenched materials are published as, **Lattice Defects in Quenched Metals**, ed. by R. M. J. Cotterill, M. Doyama, J. J. Jackson, and M. Meshii (Academic Press, New York, 1965).



STANDARDS AND CALIBRATION

SUMMARY OF 1965–66 NBS PRECISION MEASUREMENT SEMINARS

Because of delays occasioned by the move of the NBS Washington laboratories to Gaithersburg, Md., then just getting under way, the 1965–66 Precision Measurement Seminars were announced scarcely 2 months before they were to start. Despite this, only one seminar (*Low Temperature*) had a smaller number of students than it could have accommodated; and two of the seminars (*Length* and *Precision and Accuracy*) were each repeated an extra, unscheduled, time because registrations were so large. Altogether there were 219 attendees, primarily top-level technical personnel of standards laboratories in industry and other government agencies, but including a handful of people from university laboratories.

The *Low Frequency Electrical Standards* seminar was held Dec. 8–10 with 45 attendees. Following an introduction by Dr. Chester Page, lecture topics and speakers were: absolute electrical measurements and basic electrical standards by Dr. F. K. Harris; resistance, inductance, and capacitance standards and measurements by C. Peterson and J. Morrow; and voltage, current, and power measurements by F. L. Hermach and B. L. Dunfee. Other members of the Institute for Basic Standards (IBS) staff who assisted in a professional capacity were R. Dzuiba, E. S. Williams, and T. Wells. Participants were divided into small groups for the laboratory demonstrations which were given one afternoon and one morning.

In the *Low Temperature* seminar, which met Jan. 11–13, there were 24 registrants, although 30 could have been accommodated. The principal subjects were: theory and procedures for platinum resistance thermometers for 273 to 14 °K; temperature measurement with the NBS acoustic and germanium resistance thermometers; and thermocouples in cryogenic engineering. Lecturers were Dr. H. Plumb, J. Riddle, and R. Powell.

Because of the large demand, the *Length* seminar was given twice, Feb. 7–11 and Mar. 14–18, with a combined registration of 47. Lecture subjects were: philosophy of measurement, fundamental interferometry, electro mechanical transducer evaluation and calibration, deformation theory, spectral light sources and lasers. Laboratory work dealt with methodology in the measurement of gage blocks, polygons, surface plates, angle blocks, optical flats, surface finish, spherical and cylindrical diameters, and deformation. Instructors, all from the Metrology Division of the IBS, were: J. S. Beers, J. L. Chamberlin, J. M. Fath, D. A. Lorenzen, Dr. K. Mielenz, D. B. Spangenberg, A. G. Strang, C. D. Tucker, and R. C. Veale; plus A. G. McNish, Chief of the Metrology Division, and T. R. Young, Chief of the Length Section, who also organized the seminar.

Restricted originally to 15 persons, the *Precision and Accuracy* seminar was given twice, Feb. 14–16 and Feb. 23–25, with a total registration of 38. Dr. R. D. Huntoon, Director of the IBS, launched the meetings by presenting a broad review of the national measurement system, aspects of which were then elaborated by Dr. C. Eisenhart, NBS Senior Research Fellow, P. E. Pontius of the IBS Mass and Volume Section, and J. M. Cameron of the IBS Statistical Engineering Laboratory (SEL). Dr. W. J. Youden, formerly of NBS and now on the faculty of George Washington University, discussed the design of experiments useful for evaluating systematic errors. The part that data processing computers can play in checking observations and analyzing results of calibration work was discussed by J. Hilsenrath, IBS Heat Division. Propagation of error in a chain of calibrations was analyzed by Dr. J. R. Rosenblatt, SEL; and H. H. Ku, SEL, discussed problems associated with calibration curves. Problem sessions, conducted by Dr. T. A. Willke, SEL, completed the program.

A 4-day seminar, *High Frequency and Microwave Noise*, was held Mar. 1–4 at the NBS Boulder (Colo.) laboratories, sponsored by the IBS Radio Standards Laboratory (RSL). Lectures and laboratory demonstrations were presented to 29 registrants by RSL staff members. After an introduction by Dr. J. M. Richardson, Deputy Director of IBS for Radio Standards, the generation and measurement of high frequency noise were discussed in sessions conducted by M. G. Arthur, W. C. Daywitt, L. D. Driver, and R. L. Martin. Instructors for sessions on high-temperature and cryogenic noise standards and measurements at microwave frequencies were W. C. Daywitt, C. K. S. Miller, C. L. Trembath, and Dr. D. F. Wait, an NBS Senior Research Fellow. H. Wassink contributed a session on plasmas as noise sources.

The seminar on *High Frequency and Microwave Field Strength* met Mar. 7–9 at the NBS Boulder laboratories, again under RSL sponsorship; there were 36 registrants. The program was tailored to the needs of those concerned with antenna standards and their derivation, and with the measurement of field strength at frequencies from VLF to microwaves. Theoretical discussions and laboratory demonstrations were presented by nine RSL staff members and two from ITSA (Institute for Telecommunication Sciences, formerly part of NBS Central Propagation Laboratory and now in ESSA). Sessions on antenna gain were led by R. W. Beatty, R. R. Bowman, R. G. Fitzgerrell (ITSA), and J. E. Adams (ITSA); on near-field measurements, by F. M. Greene; on low (30 Hz to 30 MHz) and high (30 to 1000 MHz) frequency field strength stand-

continued

STANDARDS AND CALIBRATION *continued*

ards and measurements, by F. M. Greene, H. E. Taggart, and M. G. Arthur; on calibration of field strength meters and loop and dipole antennas, by H. E. Taggart; on calibration of horn antennas and evaluation of anechoic chambers, by R. R. Bowman; and on antenna measurements at arbitrary distances by Drs. D. M. Kerns, R. C. Baird, and P. F. Wacker.

CALIBRATION SERVICE FOR MICROWAVE POWER IN WR 187 WAVEGUIDE (3.95 to 5.85 GHz)

The NBS Radio Standards Laboratory at Boulder, Colo., announces a calibration service for the measurement of effective efficiency and calibration factor of bolometer units and bolometer-coupler units in WR 187 waveguide. Although calibrations can be performed at any frequency in the useful range of the waveguide (3.95–5.85 GHz), it is more economical to the customer if calibrations are performed at the selected [1] frequencies of 4.35, 4.90, and 5.25 GHz.

The quantities measured in these services have the following definitions: [2]

Effective efficiency for bolometer units: the ratio of the substituted d-c power in the bolometer unit to the microwave power dissipated within the bolometer unit.

Calibration factor for bolometer units: the ratio of the substituted d-c power in the bolometer unit to the microwave power incident upon the bolometer unit.

Calibration factor for bolometer-coupler units: the ratio of the substituted d-c power in the bolometer unit on the side arm of the directional coupler to the microwave power incident upon a nonreflecting load attached at the output port of the main arm.

Because of certain limitations in adapting the microwave microcalorimeter to measurement of power in the larger waveguide sizes, the effective efficiency and calibration factor of bolometer units in WR 187 waveguide are measured somewhat indirectly by using a working standard that has been calibrated by the impedance method.[3 4 5] The impedance technique yields a direct measurement of the efficiency of a bolometer unit. However, this efficiency measurement usually is of special interest only. The efficiency is defined as the ratio of microwave power absorbed by the bolometer element to the microwave power dissipated within the bolometer unit.

The effective efficiency and calibration factor of a bolometer unit, as well as the calibration factor of a bolometer-coupler unit, are measured with an uncertainty no greater than 2 percent in the WR 187 waveguide. For these measurements the element can be of the barretter or thermistor type, and of either 100- or 200-ohm resistance, operating at a bias current between 3.5 and 15 mA. The bolometer unit can be of either the fixed-tuned or untuned broadband type. Power measurements can be made on bolometer units over a range of 0.1 to 10 mW.

Power measurements can be made on bolometer-coupler units in WR 187 waveguide with coupling ratios from 3 to 20 dB. A bolometer unit of either the fixed-tuned or untuned broadband type must be permanently attached to the side arm of the coupler. The coupler should have a directivity of no less than 40 dB, and a VSWR no greater than 1.05 for the input and output ports of the main arm of the coupler.

CALIBRATION SERVICES FOR WAVEGUIDE REFLECTORS IN WR 112 AND WR 187 WAVEGUIDE

Calibration services for the measurement of reflection coefficient magnitude of waveguide reflectors (mismatches) in WR 112 and WR 187 waveguides have been announced by the Radio Standards Laboratory (Boulder, Colo.). Similar calibration services in three other waveguide sizes, WR 137, WR 90, and WR 62, are already available.

The calibration can be performed at any frequency within the ranges of the waveguides: 7.05 to 10.0 GHz for WR 112 or 3.95 to 5.85 GHz for WR 187. However, it is more economical for the customer if calibrations are performed at the selected [1] frequencies of 7.75, 8.50, and 9.00 GHz for the WR 112 waveguide and 4.35, 4.90, and 5.25 GHz for the WR 187 waveguide.

Measurements can be made over the range from 0.024 to 0.2, with an uncertainty of the reflection coefficient magnitude expressed as $\pm(0.0002+0.002|\Gamma|)$, where $|\Gamma|$ is the numerical value of the measured magnitude.

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz
WWVH—2.5, 5.0, 10.0, and 15.0 MHz
WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. Adjustments are made at 0000 UT (7:00 p.m., e.s.t.) on the first day of a month. There will be no adjustment made on 1 January 1967. The pulses occur at intervals that are longer than 1 second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure, Paris, France.

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. NBS

directs that such adjustments be made in the scale at intervals to maintain the seconds pulses within about 100 ms of UT2. There will be no adjustment made on 1 January 1967.

There was an adjustment in the phase of seconds pulses emitted from radio station WWVB, Fort Collins, Colorado on 15 December 1966. The clock at the station was retarded by 114.7638 ms at 0000 hours UT 15 December 1966 (7:00 p.m., e.s.t. of 14 December 1966).

This phase adjustment ensures that the emitted pulses from station WWVB will remain within approximately 100 ms of UT2 and at the same time differ from the atomic time scale maintained by NBS by an integral multiple of 200 ms. The adjustment will also facilitate intercomparison of the broadcast time scale with those of other laboratories.

[1] In performing microwave calibrations, a considerable amount of time usually is needed to prepare the system for measurement operation. Much of this preparation is related to adjustment of the system to the frequency of operation selected for the calibration. Time and cost often can be reduced by minimizing the number of times the operating frequency of the calibration system must be readjusted.

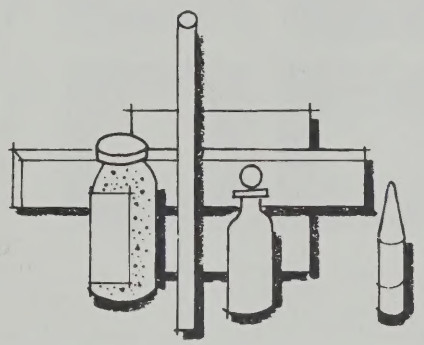
[2] **Bolometric microwave power calibration techniques at the National Bureau of Standards**, by R. F. Desch and R. E. Larson, IEEE Trans. on Instrumentation and Measurement, **IM–12**, No. 1, June 1963.

[3] **Determination of efficiency of microwave bolometer mounts from impedance data**, by David M. Kerns, J. Res. NBS **42**, 579 (1949) RP 1995.

[4] **An improved method of measuring efficiencies of ultra-high-frequency and microwave bolometer mounts**, by R. W. Beatty and Frank Reggia, J. Res. NBS **54**, 321 (1955) RP 2594.

[5] **A bolometer mount efficiency measurement technique**, by G. F. Engen, J. Res. NBS **65C**, 113 (1961).

STANDARD REFERENCE MATERIALS



TEARING STRENGTH STANDARD FOR PAPER RENEWED

A little more than 4 years ago, the National Bureau of Standards issued its first standard reference material for tearing strength of paper.[1] This standard, NBS No. 704, was issued to increase the accuracy of measuring the internal tearing strength of paper. The supplies of NBS Standard No. 704 are now exhausted. However, because of continued demand for a tearing strength standard for paper, NBS has reissued the standard as No. 704a to replace No. 704.

To obtain predictable best results in service, the physical properties of paper must be closely controlled. To this end, the Technical Association of the Pulp and Paper Industry has a test method, TAPPI Standard T414 ts-65, Internal Tearing Resistance of Paper, which recommends the use of the NBS standard reference material. This recommendation and the initial development of the tear standard sample were sponsored by the API-TAPPI Reference Materials Committee, and involved a cooperative effort of the API (American Paper Institute—formerly the American Pulp and Paper Association), TAPPI, the Institute of Paper Chemistry (IPC), and the National Bureau of Standards. Periodic checks are made between NBS and IPC to assure proper assignments of values to the standard reference material.

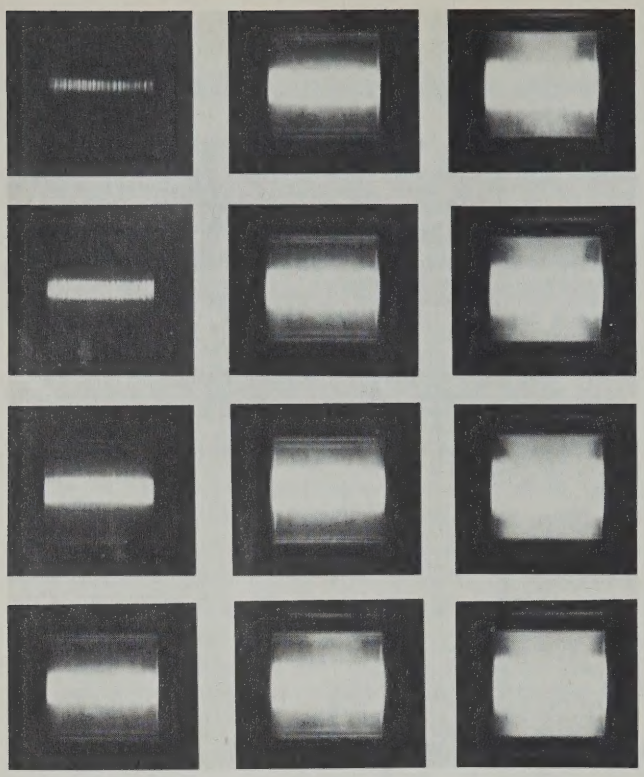
NBS Standard No. 704a, costs $7.00 a package. It is available on a subscription or individual package basis, as was No. 704. The API-TAPPI Committee has recommended that initial subscriptions be for 12 monthly shipments ($84.00). If experience shows satisfactory performance, frequency of calibration may be reduced to a quarterly basis, or even lower frequency.[2] Criteria for reduced frequency are included in the instructions shipped with the standard sample. When ordering a quarterly subscription (4 shipments, $28.00), specify the months in which shipments are to be made. Subscription orders once entered cannot be changed during the term of the subscription.

Each package of NBS Standard 704a contains approximately 120 sheets, 6 in. x 9 in., sufficient to make more than forty 16-ply specimens. Purchase orders should be sent to the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234.[3]

[1] **Tearing strength standard for paper**, Standard Materials, NBS Tech. News Bull. **46**, No. 6, 72–73 (June 1962), also Tappi **45**, No. 7, 127A (July 1962).

[2] **Frequency of paper strength calibrations may be reduced**, Standard Materials, NBS Tech. News Bull. **47**, No. 9, 168 (September 1963), also Tappi **46**, No. 11, 126A (Nov. 1963).

[3] For a complete list of NBS standards, see Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards, NBS Misc. Publ. 260, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents.



NBS Studies Light From Exploding Wires

The framing camera record of an exploding aluminum wire shows the growth of the explosion for the period from 8 μsec to 19 μsec after current initiation. Between 10 and 15 μsec the arc is sharply defined and there is little mixing between metal vapor and the surrounding air; then, at 16 μsec ejected particles and reaction products begin to envelop the columns.

The high-intensity, pulsed light from electrically exploded wires is used to pump lasers, to produce intense radiation for flash photolysis experiments, and to produce atomic and molecular species for spectroscopic studies. The NBS Institute for Basic Standards is currently utilizing the exploding wire as a laboratory technique for studying atomic and molecular processes at high temperatures. This study is being conducted for the Air Force Office of Scientific Research by E. C. Cassidy and S. Abramowitz.

Capacitor discharge currents as high as 150,000 amperes at 14 to 20 kV are employed to explode wire samples of selected metals, such as aluminum and titanium. The wires, which are about 0.1 mm in diameter and 10 cm long, are exploded in sealed cylindrical vessels charged with argon, oxygen, hydrogen, or nitrogen at controlled pressures between 0.01 and 1 atm. Glass vessels with demountable quartz windows have been found most suitable for the spectral studies because the glass, unlike polymeric materials, does not produce features in the spectrum. At the levels of energy being applied, a wall thickness of 4 mm is required to prevent explosion of the vessel.

A high-speed framing camera is used to observe the growth of the explosion with time. A high-speed drum camera is focused on the focal plane of a spectrograph to record the time history of the explosion spectrum. More detailed information on the spectrum at selected intervals is obtained from time-resolved photographic plates of the spectrum, taken with the aid of a rotating shutter disc.[1]

Thus far, results have suggested a method for estimating the average temperature of the exploding metal vapor at certain intervals during the explosion.[2] Methods have also been devised for time-resolved measurements of electrical current, voltage, power and energy dissipation during the explosive discharge.[3]

The spectral studies have shown that the explosion produces intense continuum radiation for about 100 microseconds. After this period, the spectral distribution depends upon the wire material and the environment. Aluminum wires exploded in argon and nitrogen produce numerous atomic lines from the wire material (and its impurities). As the intensity of the continuum declines, the lines become more distinct and endure for several milliseconds. Most of the lines appear in emission. The interval between 600 and 1100 microseconds after initiation of the discharge current has been found most suitable for spectral study of these systems.

NBS PRECISION MEASUREMENT SEMINARS 1966-67

NBS Precision Measurement Seminars for 1967

In continuation of the program of Precision Measurement Seminars held at the National Bureau of Standards since the fall of 1963, the group of topics listed below is planned for the spring of 1967. The purpose is to present information on the problems of standards laboratories in measuring physical quantities and calibrating instruments primarily at levels of accuracy used at the Bureau in its calibration services. The program is part of a broader NBS effort to provide advice and assistance on measurement and calibration problems met by the growing number of standards laboratories serving either research or production activities in industry, in the universities, and in other government agencies.

The seminars are open to a limited number of persons from measurement and standards laboratories who meet appropriate prerequisites relating to education, work experience, and current professional activity. The sessions will include lectures and group discussions, supplemented by laboratory demonstrations. Seminars will last from 3 to 5 days and will be held at the NBS facilities at Gaithersburg, Md., or at Boulder, Colo., depending on the subject matter. The registration fees to be charged cover the estimated added cost to the Bureau.

Seminars will be offered in the following fields, provided there is sufficient registration in each:

Precision and Accuracy in Measurement and Calibration (G)*
Calorimetry (G)
Thermocouples and/or Optical Pyrometers (G)
Phase Shift: LF, HF, and MW (B)**
High Frequency Voltage (B)

The suggestions of laboratory directors as to topics to be treated in future seminars will be welcomed. They should be sent to Dr. H. L. Mason, Assistant to the Director, Institute for Basic Standards, National Bureau of Standards, Washington, D.C. 20234. Three seminars which had been tentatively scheduled for the spring of 1967—Length, Low Frequency Electrical Measurements, Time and Frequency—are now shifted to the fall of 1967.

Application procedure: Laboratory directors interested in having qualified members of their staff attend any of these seminars should address a letter of application to the individual named in the description of the seminar given below.

Since requests for enrollment usually exceed the number of attendees who can be accommodated, application should be made as soon as possible, and should give full details of the candidates' qualifications in terms of the stated prerequisites. Applications should also be accompanied by a check, billing authorization, or purchase order for the stated fee.

Acceptance of qualified applicants, on the basis of first come first served, will be made by letter not later than four weeks prior to the scheduled date of the seminar. Detailed information on schedules and housing will be available at that time, and refund will be made to applicants not accepted. Those accepted will be expected to study the assigned reading material before coming to the seminar, and should be prepared to discuss their own experiences with related problems.

Precision and Accuracy in Measurement and Calibration (G)

Brief description: A 4-day seminar dealing with the following topics: Measurement—qualitative and quantitative aspects. Errors, residuals, precision, accuracy. Quality control of a measurement process, control charts. Measurement of the precision and assessment of the accuracy of a measurement process. Expression of the uncertainties affecting a measurement value. Propagation of error, recording of data, protection against outlying data. Experimental designs for calibration. Computer procedures.

Prerequisites: Applicants must have undergraduate college training in engineering or physics and must be currently engaged at a professional level in metrology or calibration. Preparation should include review of "ASTM Manual on Quality Control of Materials," Special Publication 15–C; E. B. Wilson, *An Introduction to Scientific Research,* ch. 7, 8, and 9; Churchill Eisenhart, *Realistic Evaluation of the Precision and Accuracy of Instrument*

Calibration Systems, NBS Journal of Research 67C, pp. 161–187 (April–June 1963). A list of references and selected articles will be sent to participants.

Arrangements: Group will be limited to 50 selected on the basis of academic qualification and experience. Fee, $100. Scheduled dates: February 13–16, 1967. Apply to J. M. Cameron, Applied Mathematics Division, National Bureau of Standards, Washington, D.C. 20234.

Calorimetry (G)

Brief description: This 4-day seminar will cover the general field of calorimetry. Most of the seminar will be devoted to experimental methods and techniques used in accurate calorimetry. Subjects covered will include low and high temperature calorimetry, combustion and reaction calorimetry, microcalorimetry, automation of calorimetry, principles of calorimetric design, etc. The seminar will consist of lectures, discussions, and visits to NBS calorimetric laboratories.

Prerequisites: Candidates must have undergraduate college-level training in physics, physical chemistry, or engineering and be involved in experimental calorimetry, either directly or in a supervisory capacity. Prior to the seminar, candidates will be furnished copies of some of the material to be covered in the seminar.

Arrangements: Attendance will be limited to 30 people. Fee, $150. Tentative dates: May 15–19, 1967. Apply to D. C. Ginnings, Heat Division, National Bureau of Standards, Washington, D.C. 20234.

Thermocouples and/or Optical Pyrometers (G)

This seminar will be divided into two parts, as indicated below. The information under "General" is relevant to both parts.

Part I

Brief description: Part I will cover the calibration of common types of thermocouples and thermocouple materials by the comparison method and by the fixed point method. Procedures for the calibration of refractory and noble metal thermocouples by direct comparison with an optical pyrometer will also be covered. Special experimental techniques will be described and laboratory demonstrations will be included.

Prerequisites: Candidates must have undergraduate, college-level training in engineering or physics, or equivalent experience, and must be currently engaged at a professional level in standards work involving the precision calibration of thermocouples. Preparation for the seminar should include a review of NBS Handbook 77, Vol. II, pages 68–110, NBS Circular 590, and NBS Monograph 37.

Dates: May 22–24, 1967, with the afternoon of May 24 open for additional informal discussion if desired.

Part II

Brief description: Part II will cover the theory used in realizing the International Practical Temperature Scale and in determining brightness temperatures of nonblackbodies with an optical pyrometer. Experimental apparatus and techniques used in primary and secondary calibrations will be discussed and demonstrated. New problems and precautions relating to high-precision photoelectric pyrometers will also be included.

Prerequisites: Candidates must have undergraduate, college-level training in engineering or physics, or equivalent experience, and must be currently engaged at a professional level in standards work involving the precision calibration of optical pyrometers. Preparation for the seminar should include a review of NBS Monographs 37 and 41 and the paper on the NBS photoelectric pyrometer appearing in the October 1966 issue of *Metrologia*.

Dates: May 24 (afternoon), May 25, and May 26 (morning), 1967, with the afternoon of May 26 open for additional informal discussion if desired.

General

Special Session: In the morning of May 24 a discussion and description of the International Practical Temperature Scale will be held; attendees at either part of the seminar are invited.

Registration Fees: A fee of $150 will be charged for each part of the seminar, or $250 for those wishing to attend both parts. Reprints of the material required for study prior to the seminar will be mailed to prospective attendees with the notice of their acceptance.

Note: This seminar is a repeat, with some updating, of the seminar given in December of 1964. Because of space restrictions for laboratory demonstrations, only a limited number of applicants will be accepted. Applications should be directed to J. F. Swindells, Temperature Section, National Bureau of Standards, Washington, D.C. 20234.

Phase Shift: Low Frequency, High Frequency, and Microwave (B)

Brief description: This 3-day seminar will cover topics of interest to those concerned with the measurement of phase shift at frequencies from LF through the microwave regions. Topics of discussion will include definitions of terms, phase shift equations, phase shift devices, phase shift measurement techniques, measurement errors, and time delay measurement techniques. Emphasis will be on phase shift measurement techniques in use at the National Bureau of Standards, and the accuracy limitations of these techniques. Discussions will be supplemented by laboratory demonstrations.

Prerequisites: Candidates must have college undergraduate level training in engineering or physics, or equivalent experience, and must be currently engaged in precision measurement at a professional level.

Arrangements: Attendance will be limited to approximately 30 people. Fee, $120. Scheduled dates, June 12–14, 1967. Apply to Doyle A. Ellerbruch, Microwave Circuit Standards, Radio Standards Laboratory, National Bureau of Standards, Boulder, Colo. 80302.

High Frequency Voltage (B)

Brief description: This 3-day seminar will cover standards and calibration techniques of voltages at frequencies of 30 kHz to 1 GHz, with emphasis on NBS ECC (Echelon I) and standardization laboratories (Echelon II) activities. National primary standards and techniques, and electric field distributions in coaxial and hollow waveguides will be discussed. Voltage standards for levels from a microvolt to several volts will be the major area; a lecture and demonstration will be presented on extension of the magnitudes by attenuators. Effect of noise as related to voltage measurements will be analyzed. Lecture demonstrations will be presented on pulse-peak voltage measurements and calibrations. Other topics of discussion will include principles, theory, description, and error analyses of h-f voltage bridges, cathode-ray tube voltage standards, A-T voltmeters, rf micropotentiometers, voltage Tee's, thermal converters, attenuators, precision pulse-peak voltmeter, high voltage calibration consoles, microvolt calibration consoles, applications of interlaboratory standards. Approximately 30 lectures, discussions, and demonstrations are planned, some of them to be presented simultaneously to three groups.

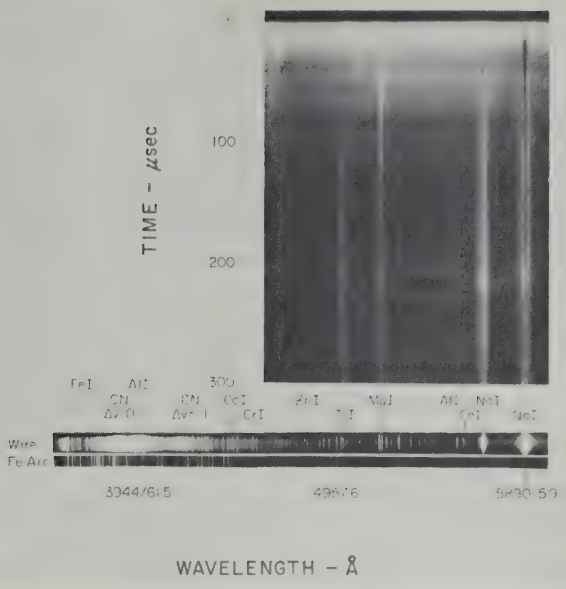
Prerequisites: Candidates must have college undergraduate level training in engineering or physics, or equivalent experience, and must be engaged currently in precision measurement at a professional level.

Arrangements: Attendance is limited to 30 persons. Fee, $120. Scheduled dates: June 7–9, 1967. Apply to M. C. Selby, Scientific Consultant, Radio Standards Laboratory, National Bureau of Standards, Boulder, Colo. 80302.

*(G) indicates seminar to be held at Gaithersburg, Md.

**(B) indicates seminar to be held at Boulder, Colo.

Continuous and time-resolved spectroscopic records obtained from an aluminum wire exploded in nitrogen by use of a NBS drum camera and a rotating shutter disc, respectively.



With aluminum wires exploded in oxygen, chemical reaction occurs in less than 50 μsec, and A1O bands are observed for several milliseconds, first in absorption and then in emission. Aluminum wires in hydrogen produce A1H bands in absorption between 50 and 500 μsec after initiation of the discharge. These bands do not appear in emission.

The initial continuum radiation from titanium wires is more intense, by a factor of 5 to 10, than that from aluminum wires. The spectral distributions from titanium wires in argon, nitrogen, and hydrogen are nearly identical. Continuum radiation is predominant for about 100 μsec; then numerous lines from atomic and ionic species appear and endure for several milliseconds. Titanium wires exploded in oxygen at 0.76 torr pressure show a similar complex line spectrum. At higher oxygen pressures, the initial continuum intensity is increased, and after about 100 μsec TiO bands appear in absorption. The intense continuum produced by titanium wires in oxygen at pressures greater than 76 torr covers the entire wavelength range from 2200 to 6200 Å. Because of the great intensity and broad wavelength coverage of these systems, exploding titanium wires are now being used as a secondary source of ultravoilet continuum radiation for absorption studies of the A1H and A1O bands produced by exploding aluminum wires.

[1] For technical details, see Rotating shutter for time-resolved spectroscopy in the microsecond range, by I. R. Bartky and A. M. Bass, Appl. Opt. 4, 1354 (1965).

[2] For technical details, see Photographic and spectroscopic studies of exploding wires in a sealed vessel, by E. C. Cassidy and K. K. Neumann, Proc. 7th International Congress on High-Speed Photography, Zurich, Switzerland, Sept. 1965 (in press).

[3] Time-Resolved electrical measurements in high current discharges, by E. C. Cassidy, S. W. Zimmerman, and K. K. Neumann, Rev. Sci Instr. (Feb. 1966).

Mrs. E. C. Cassidy switches on the high voltage (power supply to right of switch bank) for an exploding wire experiment. The delay circuits (extreme right) synchronize the monitoring drum camera (control unit at top left of switch box), framing camera (control unit below drum camera control), rotating spectrograph shutter disc, and oscilloscopes (left) with the highly transient explosion.

NSRDS NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data.

Experiments in Citation Indexing and Bibliographic Coupling

The Office of Standard Reference Data is conducting experiments to gain familiarity with remote on-line access to computers, and to explore the use of citation indexing and bibliographic coupling for solving retrieval problems.

The Office has obtained limited access to Project MAC's large computer at Massachusetts Institute of Technology. This computer has unexcelled facilities for remote on-line access and contains a large file of bibliographic references from the periodical literature in physics. The only file of its kind, it is completely computerized, and therefore uniquely suited for these experiments. The file lists all papers in recent volumes of leading physics journals, as well as the literature references cited in them. Thus it is possible to search for recent papers citing an older paper, and to search for papers which have citations in common with another paper.

Such sharing of citations ("bibliographic coupling") implies that the papers pertain to related subjects, although this is not necessarily true. Suppose, for example, that a scientist wishes to find the latest value for the atomic weight of some element. He knows that this was measured some years ago, and that it may have been revised since. He enters the index with the latest publication on this subject known to him—perhaps 5 or 10 years old—in the hope that a subsequent revision would reference the previous result. This kind of problem occurs frequently in operations such as those of the NSRDS data centers.

Other applications of a citation index are preparing bibliographies, maintaining awareness of current programs, and finding reviews of a paper or corrections to it. These examples may suffice to show that a citation index is a useful tool in many scientific undertakings, and particularly applicable in a system such as NSRDS.

Studies of long-distance access to computers may result in retrieval of data stored in computers all over the country by customers using inexpensive general-purpose terminal facilities. The technology for doing this is already in existence and may soon be used for a variety of purposes. Remote computer terminals may shortly be within easy reach of many scientists and engineers. At that time access to a central computer file of standard reference data is a service which NSRDS should be prepared to offer.

ORNL Atomic and Molecular Processes Information Center

The Atomic and Molecular Processes Information Center (AMPIC) is one of about a dozen information centers operated by the Oak Ridge National Laboratory. It began operation in 1965 to obtain, codify, evaluate, review, and retrieve data on atomic and molecular processes. AMPIC functions through the part-time use of 5 experienced scientists at the Laboratory and consulting contracts with 10 scientists at 5 universities here and abroad. In addition, one full-time computer specialist is assigned to the Center. The overall effort is sponsored jointly by the NBS Office of Standard Reference Data and the Atomic Energy Commission's Division of Technical Information.

Scientific interest in physical and chemical processes on an atomic scale has expanded from the study of modest laboratory gas discharges to include potential thermonuclear plasmas, astrophysical systems, and magneto-hydrodynamic phenomena, as well as numerous gas and plasma systems not in thermodynamic equilibrium (such as lasers). Collisions of a binary, and less frequently, of a ternary nature dominate this fourth state of matter—the plasma state. New data in many fields of particle collision physics are continually being revealed and must be presented in useful data forms for the applied scientist.

Areas of major interest to AMPIC include:

(1) The interaction of heavy particles with other heavy particles.

(2) Electron and heavy particle interactions with macroscopic matter.

(3) The effects of static or quasi-static electric and magnetic fields on heavy particles, especially those in excited states.

Bibliographies in these and several contiguous areas have been issued for 1963 and 1964. The 1965 bibliography is in process.

Besides the many routine tasks of scientific appraisal and codification on the proliferating literature on atomic and molecular processes, the Center is underwriting critical reviews of published and unpublished data in the fields of ion-atom rearrangement collisions and of ionization, excitation, and dissociation by heavy particles. Other monograph-type reviews are also contemplated. In addition, the Center serves as a sort of clearing house for technical information in its subject field.

Requests for information should be directed to Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tenn. 37830.

The Texas A&M Thermodynamics Properties Data Center

The Texas A&M Thermodynamics Properties Data Center produces scientific data on a large number of diversified yet related sets of property values such as physical, P–V–T, thermochemical, thermodynamic, and spectral properties of importance to technology and research.

The present extensive activities of the Center are the result of 24 years of continuously expanding effort in the field of critical data compilation beginning with the creation of the American Petroleum Institute Research Project 44 in 1942, at the National Bureau of Standards in Washington, D.C.

Two relocations, to Carnegie Institute of Technology, Pittsburgh, Pa., in 1950, and to Texas A&M University in 1961, with interim expansion to include the Manufacturing Chemists Association Research Project in 1955 and affiliation with the NBS Office of Standard Reference Data in 1964, have resulted, through the coordinated efforts of the sponsoring agencies, in the evolution of a unique scientific data center. Until 1960 the combined projects were directed by Frederick D. Rossini who was succeeded by Bruno J. Zwolinski.

The staff of 12 to 15 experienced professionals, supported by editorial and office personnel, are engaged in extensive literature search and selection, evaluation, and correlation of data, as well as theoretical and experimental research leading to the preparation of physical, thermodynamic, and spectral data for:

(1) Hydrocarbons and related compounds (American Petroleum Institute Research Project 44).

(2) Organic and inorganic compounds of importance to the chemical industry. (Formal connection with the Manufacturing Chemists Association was discontinued in June 1966, but the compilation work in this area will continue in the same manner under the NBS research project and the Thermodynamic Research Center data project.)

Semiannual supplements of looseleaf sheets in the form of numerical and spectral data tables are published for the catalogs of each of these two projects in six separate categories. As of June 1966, the combined catalogs of the projects included 3,126 valid sheets of physical and thermodynamic properties with 430,046 individual numerical values for 5,084 compounds representing 344 classes of compounds in 50 property tables plus 8,616 valid sheets of spectral data. Cooperating experts, member subscribers, purchasers and discount purchasers located throughout the free world make up a total of 1,780 recipients of these publications.

Through a cooperative arrangement with American Petroleum Institute Research Project 58B at Carnegie Institute of Technology, the Center has access to a large collection of very high purity hydrocarbon samples for use in the Center's experimental program. Methods of predicting and correlating properties are developed and used when reliable experimental data are not available. An 11-member American Petroleum Institute Advisory Committee headed by William O. Taff, Esso Research Laboratories, Linden, N.J., provides guidance and liaison with industry.

The aim of the Center is to fulfill the urgent need for continuing critical analysis and to reduce currently published laboratory data into tables of "best" selected physiochemical values in a usable form for basic and applied research.

New Publication: The Band Spectrum of Carbon Monoxide

The aims of molecular spectroscopy include the determination of energy levels, molecular constants, and potential energy curves and the elucidation of the electronic structure. Such data are of use to spectroscopists, astronomers, and those scientists who are interested in thermodynamic and transport properties, and chemical kinetics. These data are especially significant in the case of diatomic molecules, because of the depth of analysis that can be made of a two-atom system.

There exists no unified up-to-date compilation of spectroscopic data for diatomic molecules. The standard references in use are incomplete and out of date. Major revisions and updating are in progress but rapid accumulation of new data has created the need for a current critical review and more extensive compilation.

*NSRDS–NBS–5, The Band Spectrum of Carbon Monoxide,** by Paul H. Krupenie, the first publication in a series on diatomic molecules, reviews the literature on the spectrum of carbon monoxide (CO, CO^+, and CO^{2+}) in the gas phase. It also contains a compilation of critically evaluated numerical data on band positions, molecular constants, energy levels, potential energy curves, data pertaining to transition probabilities, and other molecular properties derived from the spectrum. Estimates of reliability are given where possible.

Though the text provides no spectrograms nor does it offer discussions of topics like infrared intensities, absorption coefficients, and line-shapes and widths, NSRDS–

continued

NSRDS NEWS *continued*

NBS–5 does review and examine the papers from which the data have been extracted to construct evaluated tables. The references cited constitute a critical bibliography.

NSRDS Publication Summary

A. Publications Issued in NSRDS Series:

1. NSRDS—Plan of Operation, by E. L. Brady and M. B. Wallenstein, NSRDS–NBS–1 (15 cents).*
2. Thermal Properties of Aqueous Uni-univalent Electrolytes, by V. B. Parker, NSRDS–NBS–2 (45 cents).*
3. Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables, Si II, Si III, Si IV, by C. E. Moore, NSRDS–NBS–3 (35 cents).*
4. Atomic Transition Probabilities, Volume I, Hydrogen Through Neon, by W. L. Wiese, M. W. Smith, and B. M. Glennon, NSRDS–NBS–4 ($2.50).*
5. The Band Spectrum of Carbon Monoxide, by Paul H. Krupenie, NSRDS–NBS–5 (70 cents).*
6. Tables of Molecular Vibrational Frequencies, by T. Shimanouchi, NSRDS–NBS–6 (in press).*
7. High Temperature Properties and Decomposition of Inorganic Salts, Part I, Sulfate, by K. H. Stern and E. L. Weise, NSRDS–NBS–7 (35 cents).*
8. Thermal Conductivity of Selected Materials, by R. W. Powell, C. Y. Ho, P. E. Liley, Thermophysical Research Center, Purdue University, NSRDS–NBS–8 (in press).*

B. Other NBS Compilations of Data:

1. Selected Values of Chemical Thermodynamic Properties, Part 1, Tables for the First Twenty-Three Elements in the Standard Order of Arrangement, by D. D. Wagman, W. H. Evans, I. Halow, V. B. Parker, S. M. Bailey, and R. H. Schumm, NBS Tech. Note 270–1 (65 cents).*
2. Selected Values of Chemical Thermodynamic Properties, Part 2 Tables for the Elements Twenty-Three Through Thirty-Two, in the Standard Order of Arrangement, by D. D. Wagman, W. H. Evans, I. Halow, V. B. Parker, S. M. Bailey, and R. H. Schumm, NBS Tech. Note 270–2 (40 cents).*
3. Electron Impact Ionization Cross-Section Data for Atoms, Atomic Ions, and Diatomic Molecules. I. Experimental Data, by L. J. Kieffer and G. H. Dunn, published in *Reviews of Modern Physics*, Vol. 38, No. 1, 1–35, January 1966.** Also to be bound with related material as an NSRDS Monograph.
4. Superconductive Materials and Some of Their Properties, by B. W. Roberts, NBS Tech. Note 408 (45 cents).*
5. Microwave Spectral Tables, Diatomic Molecules, by P. F. Wacker, M. Mizushima, J. D. Peterson, and J. R. Ballard, NBS Mono. 70, Vol. I ($2.00).*
6. Microwave Spectral Tables Line Strengths of Asymmetric Rotors, by P. F. Wacker and M. R. Pratto, NBS Mono. 70, Vol. II ($3.00).*
7. Microwave Spectral Tables, Vol. III, Polyatomic Molecules with Internal Rotation, NBS Mono. 70–III (in press).*
8. Thermodynamics and Related Properties of Parahydrogen from the Triple Point to 100 °K at Pressures to 340 Atmospheres, by H. M. Roder, L. A. Weber, R. D. Goodwin, NBS Mono. 94 (75 cents).*

C. Nondata Publications from NSRDS Related Projects:

1. Bibliography on Atomic Transition Probabilities, by B. M. Glennon and W. L. Wiese, NBS Misc. Pub. 278 (55 cents).*
2. A Bibliography of Low Energy Electron Collision Cross Section Data, 1965, by L. J. Kieffer, JILA Information Center Report No. 2, April 1, 1966 (available from JILA University of Colorado, Boulder, Colo. 80302).
3. Bibliography of Atomic and Molecular Processes for 1963, by C. F. Barnett, J. A. Ray, J. C. Thompson, and E. W. McDaniel, ORNL–AMPIC–1 (July 1965).***
4. Bibliography of Atomic and Molecular Processes for 1964, by C. F. Barnett, D. A. Griffin, M. O. Krause, J. A. Ray, J. W. Hooper, D. W. Martin, E. W. McDaniel, and E. N. Thomas, ORNL–AMPIC–3 (Mar. 1966).***
5. Directory of International Workers in the Field of Atomic and Molecular Collisions, September 1965, ORNL–AMPIC–2 (Oct. 1965).***
6. Automated Computer Tape Program for Estimation of Physical Properties of Materials for which no Measurements Exist (available from the American Institute of Chemical Engineers, 345 E. 47th St., New York, N.Y.
7. Photonuclear Data Index, prepared by Photonuclear Data Group, Radiation Physics Division, NBS, NBS Misc. Publ. 277 (55 cents).*
8. Status Report—National Standard Reference Data System, April 1966, NBS Tech. Note 289 (50 cents).*
9. Information Handling in the National Standard Reference Data System, by F. L. Alt, NBS Tech. Note 290 (25 cents).*
10. Bibliography of Flame Spectroscopy, by Radu Mavrodineanu, NBS Misc. Publ. 281 (in press).*
11. A Bibliography on Ion-Molecule Reactions, January 1900 to March 1966, by F. N. Harllee, H. M. Rosenstock, and P. T. Herron, NBS Tech. Note 291 (30 cents).*
12. Coblentz Society Specifications for Evaluation of Infrared Reference Spectra, by Board of Managers, Coblentz Society, Anal. Chem. **38,** No. 9 (Aug. 1966). (Available on request from Office of Standard Reference Data or Coblentz Society.)

*Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
**Available from the Office of Standard Reference Data, National Bureau of Standards, Washington, D.C. 20234.
***Available from Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tenn. 37831.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume **50**, No. 11, November 1966. 35 cents. Annual subscription: $1.50. 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $5; foreign, $6. Single copy, $1.00.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50. Single copy, 75 cents.

OTHER NBS PUBLICATIONS

Observed phase-front distortion in simulated earth-to-space microwave transmissions, H. B. Janes and M. C. Thompson, Jr., Tech. Note 339 (May 12, 1966), 50 cents. (Formerly Central Radio Propagation Laboratory of the National Bureau of Standards, now Environmental Science Services Administration, Boulder, Colo.)

Hydromagnetic wave propagation near 1c/s in the upper atmosphere and the properties and interpretation of Pc 1 micropulsations, J. A. Dawson, Tech. Note 342 (June 30, 1966), 40 cents. (Formerly Central Radio Propagation Laboratory of the National Bureau of Standards, now Environmental Science Services Administration, Boulder, Colo.)

PUBLICATIONS IN OTHER JOURNALS

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

CHEMISTRY

Analysis of lanolin in soap, F. J. Linnig, Soap Chem. Specialties **XVLL**, No. 7, 55–57 (July 1966).

Analytical applications of microwave spectroscopy, D. R. Lide, Jr., Book, Advances in Analytical Chemistry and Instrumentation 5, 235–277 (Interscience Publ., New York, N.Y., 1966).

Chemical substructure searching with linear notations, B. A. Marron, G. R. Boltsky, and S. J. Tauber, J. Chem. Doc. **6**, 92–95 (May 1966).

Determination of glycerol in paper, E. L. Graminski and B. W. Forshee, Tappi **49**, No. 7, 324–326 (July 1966).

Electron spin resonance studies of the reaction of water-soluble polymers with hydroxyl radicals, F. Sicilio, M. Dousset, R. E. Florin, and L. A. Wall, (Proc. 150th American Chemical Society Meeting, Atlantic City, N.J., Sept. 12–17, 1965), Polymer Preprint **6**, No. 2, 958–964 (Sept. 1965).

Experimental and theoretical studies of photoionization efficiency curves for C_2H_2 and C_2D_2, R. Botter, V. H. Dibeler, J. A. Walker, and H. M. Rosenstock, J. Chem. Phys. **44**, No. 3, 1271–1278 (Feb. 1966).

Gas-phase radiolysis and photolysis of neopetane, S. G. Lias and P. Ausloos, J. Chem. Phys. **43**, No. 8, 2748–2759 (Oct. 1965).

Identification of inclusions with the electron probe microanalyzer, K. F. J. Heinrich, Am. Soc. Testing Mater. Spec. Tech. Publ. 393 (Jan. 1966).

Intramolecular insertion of isobutylidene in the vacuum ultraviolet photolysis of isobutane, E. Tschuikow-Roux and J. R. McNesby, Trans. Faraday Soc. **62**, No. 524, 2158–2163 (Aug. 1966).

Investigation of polymer pyrolysis with thermogravimetry, J. H. Flynn and L. A. Wall (Proc. 150th American Chemical Society Meeting, Atlantic City, N.J., Sept. 12–17, 1965), Polymer Preprint **6**, No. 2, 945–955 (Sept. 1965).

Mass spectrometric study of the reactions of O atoms with NO and NO_2, Erratum, J. T. Herron, J. Chem. Phys. **44**, No. 9, 3645 (May 1966).

Oxidation of asphalt flux with oxides of nitrogen, P. G. Campbell and J. R. Wright, Am Chem. Soc. Div. Petroleum Chem. **10**, No. 1, 79–89 (Mar. 1965).

Phenylhydrazono-phenylazo tautomerism. Part I. xylo-4,5,6-trihydroxy-2-oxo-1, 3-bis(phenylhydrazono) cyclohexane and 4-oxo-1-phenyl-5-phenylazo-3-pyridazine derivatives, H. S. Isbell and A. J. Fatiadi, Carbohydrate Res. **2**, No. 2, 204–215 (June 1966).

Polymerization and pyrolysis of poly-1, 2-dihydronaphthalene, L. A. Wall, L. J. Fetters, and S. Straus (Proc. 150th American Chemical Society Meeting, Atlantic City, N.J., Sept. 12–17, 1965), Polymer Preprint **6**, No. 2, 930–939 (Sept. 1965).

Radiation-induced polymerization at high pressure of 3,3,3-trifluoropropene; 4,4,4,3,3-pentafluorobutene-1; and 5,5,5,4,4,3,3-heptafluoropentene-1, D. W. Brown (Proc. 150th American Chemical Society Meeting, Atlantic City, N.J., Sept. 12–17, 1965), Polymer Preprint **6**, No. 2, 965–976 (Sept. 1965).

Solid-vapor equilibrium in the system helium-methane, M. J. Hiza and A. J. Kidnay (Proc. 1965 Cryogenic Engineering Conf., Rice University, Houston, Tex., Aug. 23–25, 1965), Book, Advances in Cryogenic Engineering 11, 338–348 Plenum Press Inc., New York, N.Y., 1966).

Status of light-element heat-capacity calorimetry at the National Bureau of Standards: a review of the high-temperature thermodynamics, of the BeO-H_2O system, T. B. Douglas, Proc. 4th Meeting Interagency Chemical Rocket Propulsion Group, Working Group on Thermochemistry, Kennedy Space Flight Center, Florida, Mar. 16–17, 1966, **I**, No. 108, 27 (Chemistry Propulsion Information Agency, Silver Spring, Md., June 1966).

The crystal and molecular structure of dichloro(1,10-phenanthroline) zinc, C. W. Reimann, S. Block, and A. Perloff, Inorg. Chem. **5**, No. 7, 1185–1189 (July 1966).

The crystal structure of the high temperature form of barium borate, $BaO \cdot B_2O_3$, A. D. Mighell, A. Perloff, and S. Block, Acta Cryst. **20**, Pt. 6, 819–823 (June 1966).

**Publications for which a price is indicated are available by purchase from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign postage, one-fourth additional). The NBS nonperiodical series are also available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151. Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.*

CLEARINGHOUSE BIBLIOGRAPHIC JOURNALS**

U.S. Government Research & Development Reports. Semimonthly journal of abstracts of R & D reports on U.S. Government-sponsored projects and list of current projects. Annual subscription (24 issues): Domestic, $30; foreign, $37.50. Single copy, $2.25.

Government-Wide Index to Federal Research & Development Reports. Companion publication to preceding; semimonthly index to reports and projects announced in Nuclear Science Abstracts, Scientific & Technical Aerospace Reports, Technical Abstract Bulletin, and U.S. Government Research & Development Reports. Annual subscription (24 issues): Domestic, $22; foreign, $27.50. Single copy, $1.75.

Technical Translations. Semimonthly journal providing lists and indexes of translations into English or western languages by translators in the United States or abroad. Annual subscription (24 issues): Domestic, $12; foreign, $16. Single copy, 60 cents.

**U.S. Government Research & Development Reports *and* Government-Wide Index *are sold by the Clearinghouse for Federal Scientific and Technical Information, NBS, U.S. Department of Commerce, Springfield, Virginia 22151.* Technical Translations *is sold by the Superintendent of Documents.*

Index to the Technical News Bulletin

Volume 50, 1966

A

Page

Absolute reflectance, Precise technique measures (Sept.) 164
Accelerometer, Easily made device calibrates (June) 94
Accurate peak pulse voltage instruments for low and medium ranges (Sept.) 162
Alkali resistance test for porcelain enamels, New (Aug.) 137
Alloy tested for strength, Titanium (Oct.) 175
Alloys, Defects described in quenched (Dec.) 233
Alloys give improved dental fillings, Spherical (Mar.) 44
Aluminum fluoride, Heat of formation of (Apr.) 56
Analysis of noble metal alloys, Rapid (June) 91
Announcement service, Fast (Oct.) 191
Arc weatherometers compared, Xenon and carbon (Jan.) 4
Archival microfilm, Research on (Sept.) 154
Assessing durability of plastic roofs (Feb.) 21
Astin elected to AAAS post (May) 81
Attenuators for laser measurements, Silicon (Oct.) 182
Award, NBS chemist receives new international (June) 97

B

Birthday, National standards transferred on NBS 65th (May) 78
Blood flow sensor—rate of flow related to electrical conductivity (Mar.) 38
Bonding of tile and paint to treated concrete (Apr.) 58
Broadcasts, WWVB adds time code to (Jan.) 15
Building components and systems, Committee to aid in precoordination of (Oct.) 176
Building houses radiation physics program, Unique (Nov.) 220
Building required for force-measurement program, Special (Nov.) 215
Building study, Contract let for (Aug.) 131
Bulk of NBS technical program is housed in seven general purpose laboratories (Nov.) 206

C

Calibration of coaxial bolometer mounts (Jan.) 12
Calibration of gas meter provers—new method evaluated (Mar.) 37
Calibration, Modification simplifies volt box (Oct.) 186
Calibration of permanent magnet standards, NMR (Sept.) 163
Calibration services for microwave power in WR 187 waveguide (3.95 to 5.85 GHz) (Dec.) 235
Calibration services for waveguide reflectors in WR 112 and WR 187 waveguides (Dec.) 235
Capacitance standard, Portable (Feb.) 33
Carbon arc weatherometers compared, Xenon and (Jan.) 4
Cartesian diver gives precise technique for density comparisons (July) 110
Catalog of calibration services revised (Jan.) 12
Cavities, New microwave discharge (Feb.) 31
Cavity wavemeter extended to 90 GHz (Oct.) 184
Cement specimens for x-ray analysis, Sturdy powder (Jan.) 7
Ceramic materials, Symposium on (Sept.) 165
Ceramic semiconductors found superconducting (Sept.) 149
Cerium praseodymium-144, New radioactivity standard: (Oct.) 177
Changes in NBS radio broadcasts (Apr.) 54
Changes in radio broadcasts (Jan.) 13
Characterization symposium, Program announced for trace (Aug.) 142
Chemically strengthened glass, Mechanical properties of (Oct.) 173
Chemist receives new international award, NBS (June) 97
Chromium sesquioxide crystals, Etching technique reveals dislocations in (July) 105
Clearinghouse for Federal Scientific and Technical Information:
- Fast announcement service (Oct.) 191
- Internship program (Jan.) 6
- NBS corrosion reference available (Oct.) 191
- Patent microfilm service available (Oct.) 191

Collaboration with industry, NBS broadens (Feb.) 26
Colorimetric determination of gaseous combustion products (Mar.) 49
Committee to aid in precoordination of building components and systems (Oct.) 176
Communication between man and computer, Direct (Apr.) 53
Comparator for voltage transformer calibrations (July) 107
Complex, The new NBS laboratory (Nov.) 200
Computer-assisted calibration (Aug.) 127
Computer system reads diagrams drawn on screen, MAGIC (Aug.) 134
Concrete, Bonding of tile and paint to treated (Apr.) 58
Conference to be held in April 1967, Thermophysics specialist (Aug.) 142
Conference, 1966 NCSL Standards Laboratory (Mar.) 48
Conference on Weights and Measures, Fifty-First National (June) 93
Constants card may be exchanged, Physical (Oct.) 191
Construction of new WWV building begun (Sept.) 161
Construction under way: four special purpose labs (Nov.) 224
Contamination on platinum surfaces, Oxygen (Feb.) 29
Contract let for building study (Aug.) 131

Page

Copper wire tables (July) 116
Corrosion dialogue, Washington (July) 116
Cross section technology, Neutron (July) 116
Cryogenic cooler for semiconductor devices (Sept.) 152

D

Data center, New mass spectrometric (Apr.) 57
Data obtained for space probes, Spectral (Jan.) 11
Data processing system speeds plasma studies (Jan.) 3
Datalogging systems, Transistorized modules for (Mar.) 42
Decomposition of multiply charged ions (May) 82
Defects described in quenched alloys (Dec.)
Dental fillings, Spherical alloys give improved (Mar.) 44
Dependence in thermopiles observed, Wavelength (Apr.) 63
Device calibrates accelerometer, Easily made (June) 94
Devices, Cryogenic cooler for semiconductor (Sept.) 152
Diagrams drawn on screen, MAGIC computer system reads (Aug.) 134
Direct communication between man and computer (Apr.) 53
Discharge cavities, New microwave (Feb.) 31
Dislocations in chromium sesquioxide crystals, Etching technique reveals (July) 105
Diver gives precise technique for density comparisons, Cartesian (July) 110
Durability of plastic roofs, Assessing (Feb.) 21

E

Easily made device calibrates accelerometer (June) 94
Eberhard heads institute (Oct.) 185
Effect of high pressure on refractive index (Sept.) 156
Effective efficiency of coaxial bolometer units at 9 GHz (July) 108
Electrical conductivity, Blood flow sensor—rate of flow related to (Mar.) 38
Electrical standards moved, National (Aug.) 125
Electromotive series for solid and molten oxides and halides (May) 80
Enamels studied, Weather resistance of porcelain (Oct.) 180
Engineering standards liaison and analysis established at NBS, Office of (Sept.) 151
Errata for handbook of mathematical functions, List of (July) 111
Etching technique reveals dislocations in chromium sesquioxide crystals (July) 105
Exploding wires, NBS studies light from (Dec.) 238

F

Facility, NBS occupies (Nov.) 198
Fast announcement service (Oct.) 191
Fees reduced at Boulder (June) 97
Fifty-first national conference on weights and measures (June) 93
Fillings, Spherical alloys give improved dental (Mar.) 44
Fires in test models, Scaling factors for (Apr.) 66
First day QSL cards, WWV to send (Nov.) 211
First IMR symposium on materials research (Apr.) 67
Flaw study initiated, Semiconductor (May) 81
Floating weather station uses nuclear power (Mar.) 40
Flow rate of liquid hydrogen determined by NMR technique (July) 109
Fluorescent lamp colors, Improved method for standardizing (Jan.) 2
Fluoride, Heat of formation of aluminum (Apr.) 56
Force-measurement program, Special building required for (Nov.) 215
Four receive Stratton and Rosa Awards, NBS honors staff scientists (Mar.) 46
Frequency and time broadcasts, NBS radio stations—standard (Mar.) 39
Frost is fingerprinted (Feb.) 20

G

Gamma ray and neutron reflection (Feb.) 30
Garstang heads JILA (Feb.) 32
Gas meter provers—new method evaluated, Calibration of (Mar.) 37
Gaseous combustion products, Colorimetric determination of (Mar.) 49
General purpose laboratories, Bulk of NBS technical program is housed in seven (Nov.) 206
Glass, Mechanical properties of chemically strengthened (Oct.) 173
Glass, Space radiation affects refractive properties of (Aug.) 138
Glass viscosity measurements extended, Range of (July) 106
Gradients, Pressure transducer response affected by thermal (Apr.) 64

H

Halides, Electromotive series for solid and molten oxides and (May) 80
Handbook of mathematical functions, List of errata for (July) 111
Heat of formation of aluminum fluoride (Apr.) 56
HF instruments, Modular technique gives accurate (Apr.) 60
High-flux reactor, NBS completes (Nov.) 212
High temperature data for rhenium (Aug.) 128
Hydrogen being studied, Slush (Jan.) 1
Hydrogen determined by NMR technique, Flow rate of liquid (July) 109

I

Page

Immittance questionnaire replies (May) ---- 83
Impact behavior, New data on textile (Jan.) ---- 8
Improved method for standardizing fluorescent lamp colors (Jan.) ---- 2
Index, Effect of high pressure on refractive (Sept.) ---- 156
Industry, NBS broadens collaboration with (Feb.) ---- 26
Insert sheets update Misc. Publ. 250 (July) ---- 108
Institute, Eberhard heads (Oct.) ---- 185
Institutes to be at Gaithersburg, Three (Nov.) ---- 199
Instruments for low and medium ranges, Accurate peak pulse voltage (Sept.) ---- 162
Instruments, Modular technique gives accurate HF (Apr.) ---- 60
International award, NBS chemist receives new (June) ---- 97
Internship program (Jan.) ---- 6
Invention shows aid industry, State (Sept.) ---- 158
Ions, Decomposition of multiply charged (May) ---- 82
IMR symposium on materials research, First (Apr.) ---- 67
Isotopic reference standards (Feb.) ---- 25

J

JILA, Garstang heads (Feb.) ---- 32

L

Laboratory complex, The new NBS (Nov.) ---- 200
Lamp colors, Improved method for standardizing fluorescent (Jan.) ---- 2
Laser measurements, Silicon attenuators for (Oct.) ---- 182
Liaison and analysis established at NBS, Office of Engineering Standards (Sept.) ---- 151
Light from exploding wires, NBS studies (Dec.) ---- 240
Line-standard fee reduced (July) ---- 108
List of available radioactive standards amended (Feb.) ---- 25
List of errata for handbook of mathematical functions (July) ---- 111
Liquid hydrogen determined by NMR technique, Flow rate of (July) ---- 109
Low-frequency calibration services centralized (Jan.) ---- 12

M

Macromolecules and virus particles, Rapid separation of (Apr.) ---- 55
MAGIC computer system reads diagrams drawn on screen (Aug.) ---- 134
Magnet standards, NMR calibration of permanent (Sept.) ---- 163
Mass spectrometric data center, New (Apr.) ---- 57
Materials of certified purity (June) ---- 92
Mathematical functions, List of errata for handbook of (July) ---- 111
Measurement activities, Systems concept applied to Nations (Oct.) ---- 178
Measurement of microwave power in WR 112 waveguide (Mar.) ---- 45
Measurements, Silicon attenuators for laser (Oct.) ---- 182
Mechanical properties of chemically strengthened glass (Oct.) ---- 173
Metal alloys, Rapid analysis of noble (June) ---- 91
Metal standards (June) ---- 92
Meter provers—new method evaluated, Calibration of gas (Mar.) ---- 37
Metrologia (Mar.) ---- 45
Microfilm, Research on archival (Sept.) ---- 154
Microwave discharge cavities, New (Feb.) ---- 31
Microwave impedance (Jan.) ---- 12
Microwave power in WR 137 waveguide (Jan.) ---- 13
Minimum venting for plumbing systems (May) ---- 75
Modification simplifies volt box calibration (Oct.) ---- 186
Modular technique gives accurate HF instruments (Apr.) ---- 60
Modules for datalogging systems, Transistorized (Mar.) ---- 42
Molecular oxygen, New energy states in (Feb.) ---- 23
Mössbauer spectroscopy, Standard reference material for (May) ---- 73
Multiply charged ions, Decomposition of (May) ---- 82

N

National conference on weights and measures, Fifty-first (June) ---- 93
National electrical standards moved (Aug.) ---- 125
Nation's measurement activities, Systems concept applied to (Oct.) ---- 178
NBS broadens collaboration with industry (Feb.) ---- 26
NBS chemist receives new international award (June) ---- 97
NBS completes high-flux reactor (Nov.) ---- 212
NBS corrosion reference available (Oct.) ---- 191
NBS honors staff scientists—four receive Stratton and Rosa awards (Mar.) ---- 46
NBS issues permittivity standards (Aug.) ---- 130
NBS occupies new facility (Nov.) ---- 198
NBS precision measurement seminars 1966–67 (Aug.) ---- 127
NBS radio stations—standard frequency and time broadcasts (Mar.) ---- 39
NBS studies light from exploding wires (Dec.) ---- 238
NBS technical program is housed in seven general purpose laboratories, Bulk of (Nov.) ---- 206
NCRP opens publication sales office (Oct.) ---- 190
NCSL 1966, Standards laboratories meet: (Aug.) ---- 132
Neutron cross section technology (July) ---- 116
Neutron reflection, Gamma ray and (Feb.) ---- 30
New alkali resistance test for porcelain enamels (Aug.) ---- 137
New data on textile impact behavior (Jan.) ---- 8
New energy states in molecular oxygen (Feb.) ---- 23
New glass standards (June) ---- 92
New mass spectrometric data center (Apr.) ---- 57
New microwave discharge cavities (Feb.) ---- 31
New NBS laboratory complex, The (Nov.) ---- 200
New programmers for WWV (July) ---- 108
New radioactivity standard: cerium praseodymium-144 (Oct.) ---- 177
New and reissued standards (June) ---- 92
New thermocouple tables (May) ---- 84
NMR calibration of permanent magnet standards (Sept.) ---- 163
NMR technique, Flow rate of liquid hydrogen determined by (July) ---- 109
Noble metal alloys, Rapid analysis of (June) ---- 91
Noisy in the inaudible range, Winds are (Feb.) ---- 19
Non-linear effects in plasmas (July) ---- 116
Notice of U.S. standard frequency and time broadcasts: Page
May ---- 83
June ---- 97
NSRDS News:
June ---- 98
July ---- 118
Aug ---- 140
Sept ---- 166
Oct ---- 188
Nov ---- 210
Dec ---- 240
Nuclear power, Foating weather station uses (Mar.) ---- 40

O

Office of engineering standards liaison and analysis established at NBS (Sept.) ---- 151
OMNITAB (July) ---- 116
Oxides and halides, Electromotive series for solid and molten (May) ---- 80
Oxygen contamination on platinum surfaces (Feb.) ---- 29
Oxygen, New energy states in molecular (Feb.) ---- 23

P

Paint to treated concrete, Bonding of tile and (Apr.) ---- 58
Patent microfilm service available (Oct.) ---- 191
Plasmas, Non-linear effects in (July) ---- 116
Plasma studies, Data processing system speeds (Jan.) ---- 3
Plastic roofs, Assessing durability of (Feb.) ---- 21
Platinum surfaces, Oxygen contamination on (Feb.) ---- 29
Physical constants card may be exchanged (Oct.) ---- 191
Plumbing systems, Minimum venting for (May) ---- 75
Porcelain enamels, New alkali resistance test for (Aug.) ---- 137
Porcelain enamels studied, Weather resistance of (Oct.) ---- 180
Portable capacitance standard (Feb.) ---- 33
Powder cement specimens for x-ray analysis, Sturdy (Jan.) ---- 7
Precise determination of millivolt a-c ratios (June) ---- 89
Precise technique measures absolute reflectance (Sept.) ---- 164
Precision measurement seminars underway (Jan.) ---- 13
Pre-coordination of building components and systems, Committee to aid in (Oct.) ---- 176
Pressure on refractive index, Effect of high (Sept.) ---- 156
Pressure transducer response affected by thermal gradients (Apr.) ---- 64
Product standardization updated (Mar.) ---- 48
Program announced for trace characterization symposium (Aug.) ---- 142
Properties of glass, Space radiation affects refractive (Aug.) ---- 138
Provers—new method evaluated, Calibration of gas meter (Mar.) ---- 37
Publication on radioactivity standards (Mar.) ---- 41
Publication sales office, NCRP opens (Oct.) ---- 190
Pulse voltage instruments for low and medium ranges, Accurate peak (Sept.) ---- 162

Q

QSL Cards, WWV to send first day (Nov.) ---- 211
Quenched alloys, Defects described in (Dec.) ---- 233

R

Radiation affects refractive properties of glass, Space (Aug.) ---- 138
Radiation physics program, Unique building houses (Nov.) ---- 220
Range of glass viscosity measurements extended (July) ---- 106
Rapid analysis of noble metal alloys (June) ---- 91
Rapid separation of macromolecules and virus particles (Apr.) ---- 55
Reactor, NBS completes high-flux (Nov.) ---- 212
Reflectance, Precise technique measures absolute (Sept.) ---- 164
Reflection, Gamma ray and neutron (Feb.) ---- 30
Refractive index, Effect of high pressure on (Sept.) ---- 156
Renewal standards (Mar.) ---- 41
Research on archival microfilm (Sept.) ---- 154
Resistance test for porcelain enamels, New alkali (Aug.) ---- 137
Rhenium, High temperature data for (Aug.) ---- 128
Roofs, Assessing durability of plastic (Feb.) ---- 21
Rosa awards, NBS honors staff scientists—four receive Stratton and (Mar.) ---- 46

S

Scale executives meet at NBS (May) ---- 83
Scaling factors for fires in test models (Apr.) ---- 66
Scintillation and semiconductor counter symposium, Tenth (May) ---- 74
Semiconductor devices, Cryogenic cooler for (Sept.) ---- 152
Semiconductor flaw study initiated (May) ---- 81
Semiconductors found superconducting, Ceramic (Sept.) ---- 149
Sensor—rate of flow related to electrical conductivity, Blood flow (Mar.) ---- 38
Silicon attenuators for laser measurements (Oct.) ---- 182
Slush hydrogen being studied (Jan.) ---- 1
Space radiation affects refractive properties of glass (Aug.) ---- 138
Special building required for force-measurement program (Nov.) ---- 215
Special purpose labs, Construction under way: four (Nov.) ---- 224
Spectral data obtained for space probes (Jan.) ---- 11
Spectrometric data center, New mass (Apr.) ---- 57
Spherical alloys give improved dental fillings (Mar.) ---- 44
Standard frequency and time broadcasts, NBS radio stations—(Mar.) ---- 39
Standard materials:
Isotopic reference standards (Feb.) ---- 25
List of available radioactive standards amended (Feb.) ---- 25
Publication on radioactivity standards (Mar.) ---- 41
Renewal standards (Mar.) ---- 41
Thermal emittance standards (Feb.) ---- 25
Standard, Portable capacitance (Feb.) ---- 33
Standard reference material for Mössbauer spectroscopy (May) ---- 73
Standard reference materials:
NBS issues permittivity standards (Aug.) ---- 130

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	Page
Materials of certified purity (June)	92
Metal standards (June)	92
New glass standards (June)	92
New and reissued standards (June)	92
Tearing strength standard for paper renewed (Dec.)	237
Three additions to publication series (Aug.)	130
Standardization updated, Product (Mar.)	48
Standardizing fluorescent lamp colors, Improved method for (Jan.)	2
Standards and calibration:	
Calibration of coaxial bolometer mounts (Jan.)	12
Calibration services for microwave power in WR 187 waveguide (3.95 to 5.85 GHz) (Dec.)	235
Calibration services for waveguide reflectors in WR 112 and WR 187 waveguides (Dec.)	235
Catalog of calibration services revised (Jan.)	12
Cavity wavemeter extended to 90 GHz (Oct.)	184
Changes in radio broadcasts (Jan.)	13
Changes in NBS radio broadcasts (Apr.)	54
Computer-assisted calibration (Aug.)	127
Effective efficiency of coaxial bolometer units at 9 GHz (July)	108
Fees reduced at Boulder (Jan.)	97
Immittance questionnaire replies (May)	83
Insert sheets update Misc. Publ. 250 (July)	108
Line-standard fee reduced (July)	108
Low-frequency calibration services centralized (Jan.)	12
Measurement of microwave power in WR 112 waveguide (Mar.)	45
Metrologia (Mar.)	45
Microwave impedance (Jan.)	12
Microwave power in WR 137 waveguide (Jan.)	13
NBS precision measurement seminars 1966–67 (Aug.)	127
New programmers for WWV (July)	108
Notice of U.S. standard frequency and time broadcasts (May)	83
Notice of U.S. standard frequency and time broadcasts (June)	97
Precision measurement seminars underway (Jan.)	13
Scale executives meet at NBS (May)	83
Standard frequency and time broadcast (Dec.)	235
Starting date of relocated WWV (Oct.)	184
Summary of 1965–66 NBS precision measurement seminars (Dec.)	235
Use of ac-dc transfer instruments (Jan.)	12
U.S. standard frequency and time broadcasts:	
July	108
Aug	127
Sept	157
Oct	184
Vacuum calibration service extended (Jan.)	13
Standards liaison and analysis established at NBS, Office of Engineering (Sept.)	151
Standards laboratories meet: NCSL 1966 (Aug.)	132
Standards moved, National electrical (Aug.)	125
Standards transferred on NBS 65th birthday, National (May)	78
Starting date of relocated WWV (Oct.)	184
State invention shows aid industry (Sept.)	158
States to receive new standards, Ten (Oct.)	181
Stratton and Rosa awards, NBS honors staff scientists—four receive (Mar.)	46
Sturdy powder cement specimens for x-ray analysis (Jan.)	7
Summary of 1965–66 NBS precision measurement seminars (Dec.)	235
Symposium on ceramic materials (Sept.)	165
Symposium to be held in 1968 (Oct.)	184
Symposium on materials research, First IMR (Apr.)	67
Symposium, Program announced for trace characterization (Aug.)	142
Symposium, Tenth scintillation and semiconductor counter (May)	74
Systems concept applied to Nation's measurement activities (Oct.)	178

T

Tables, Copper wire (July)	116
Tearing strength standard for paper renewed (Dec.)	237
Technical program is housed in seven general purpose laboratories, Bulk of NBS (Nov.)	206
Temperature data for rhenium, High (Aug.)	128
Ten states to receive new standards (Oct.)	181
Tenth scintillation and semiconductor counter symposium (May)	74
Test models, Scaling factors for fires in (Apr.)	66
Textile impact behavior, New data on (Jan.)	8
Thermocouple tables, New (May)	84
Thermal emittance standards (Feb.)	25
Thermal gradients, Pressure transducer response affected by (Apr.)	64
Thermophysics specialist conference to be held in April 1967 (Aug.)	142
Thermopiles observed, Wavelength dependence in (Apr.)	63
Three additions to publication series (Aug.)	130
Three institutes to be at Gaithersburg (Nov.)	199
Tile and paint to treated concrete, Bonding of (Apr.)	58
Time code to broadcasts, WWVB adds (Jan.)	15
Titanium alloy tested for strength (Oct.)	175
Trace characterization symposium, Program announced for (Aug.)	142
Transducer response affected by thermal gradients, Pressure (Apr.)	64
Transformer calibrations, Comparator for voltage (July)	107
Transistor reliability (July)	112
Transistorized modules for datalogging systems (Mar.)	42

U

Unique building houses radiation physics program (Nov.)	220
Use of ac-dc transfer instruments (Jan.)	12

V

Vacuum calibration service extended (Jan.)	13
Venting for plumbing systems, Minimum (May)	75
Virus particles, Rapid separation of macromolecules and (Apr.)	55
Volt box calibration, Modification simplifies (Oct.)	186
Voltage instruments for low and medium ranges, Accurate peak pulse (Sept.)	162
Voltage transformer calibrations, Comparator for (July)	107

W

Washington corrosion dialogue (July)	116
Wavelength dependence in thermopiles observed (Apr.)	63
Weather resistance of porcelain enamels studied (Oct.)	180
Weather station uses nuclear power, Floating (Mar.)	40
Weatherometers compared, Xenon and carbon arc (Jan.)	4
Weights and measures, Fifty-first national conference on (June)	93
Winds are noisy in the inaudible range (Feb.)	19
Wire tables, Copper (July)	116
WWV buildings begun, Construction of new (Sept.)	161
WWV to send first day QSL Cards (Nov.)	211
WWVB adds time code to broadcasts (Jan.)	15

X

X-ray analysis, Sturdy powder cement specimens for (Jan.)	7
Xenon and carbon arc weatherometers compared (Jan.)	4

U.S. GOVERNMENT PRINTING OFFICE: 1966 O—237–660